# Wheat Cover Crop Management Changes Corn Nitrogen Requirement, Morphology, Physiology and Profitability

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## Introduction

- Illinois is one of the 12 states that contribute nitrogen (N) and phosphorus (P) to the Upper Mississippi River Basin (UMRB) and impact water quality in Gulf of Mexico.
- Corn (*Zea mays* L.)-soybean (*Glycine max* L.) rotation is the main row cropping system in Illinois and integration of cover crops have been identified as an effective in-field management practice to reduce N losses from tile-drained row crop agriculture fields (https://www2.illinois.gov/sites/agr/Resources/NutrientLoss/Pages/default.aspx).
- WCCCs including wheat (*Triticum aestivum* L.) are often terminated 3-4 weeks before planting corn (early April). Delaying the termination increases N uptake and decreases N leaching potential but could immobilize N during corn growing season due to increased C:N ratio of wheat (Adeyemi et al., 2020).
- Corn N requirement [Maximum return to N (MRTN)] could change when WCCCs are planted prior to corn in rotation.

## Objectives

Evaluate the effect of wheat cover crop on corn morphology (plant height), physiology [leaf area index(LAI)], grain yield, N balances, and end of season nitrate-N. We hypothesized including wheat in rotation with corn decreases corn grain yield, increases corn N requirement AND balances, but potentially immobilizes soil nitrate-N leading to low end of season N.

## Experimental Design and Treatments

- Treatments were laid out in a randomized complete block design (RCBD) with split plot arrangement and 4 replicates in 2018, 2019, 2020 and 2021.
- The main plots were four cover crop treatments: (I) fallow (no-cover crop control); (II) early termination (3-4 week before planting corn); (III) late termination (at corn planting; planting green); and (IV) residual removal.
- The sub plots were N fertilizer application rates; for 2018 and 2019, the treatments were (1) 56 kg N ha$^{-1}$; (2) 112 kg N ha$^{-1}$; (3) 168 kg N ha$^{-1}$; (4) 224 kg N ha$^{-1}$; and (5) 280 kg N ha$^{-1}$, and for 2020 and 2021, the treatments were (1) 56 kg N ha$^{-1}$; (2) 112 kg N ha$^{-1}$; (3) 168 kg N ha$^{-1}$;(4) 224 kg N ha$^{-1}$; (5) 280 kg N ha$^{-1}$; and (6) 336 kg N ha$^{-1}$. A zero-N control treatment was also included in the study.

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## Materials and Methods

- Wheat (var. Agrima 446) was planted in November of the prior year for 2018 and 2019 study-years and October of the prior year for 2020 and 2021 study years. The seeding rate was 4.75 million seeds ha$^{-1}$. Wheat was top-dressed with 34 kg N ha$^{-1}$. Wheat above- and belowground biomass were collected and analyzed for C and N content by combustion method (Table 1).

**Table 1.** Wheat above- and belowground biomass and their C:N ratio as influenced by termination management (early, late, and residue removal).

| Wheat termination management | Aboveground biomass (Mg ha$^{-1}$) | | Aboveground C:N ratio | | Belowground biomass (Mg ha$^{-1}$) | | Belowground C:N ratio | |
|---|---|---|---|---|---|---|---|---|
| | **2018** | **2019** | **2018** | **2019** | **2018** | **2019** | **2018** | **2019** |
| Early | 2.20 | 0.35 | 29.39 | 21.9 | 0.62 | 0.11 | 43.29 | 42.54 |
| Late | 5.40 | 1.21 | 47.52 | 39.34 | 1.30 | 0.30 | 68.72 | 67.77 |
| Residue Removal | 5.48 | 1.29 | 48.99 | 42.48 | 1.13 | 0.31 | 72.8 | 71.08 |
| | **2020** | **2021** | **2020** | **2021** | **2020** | **2021** | **2020** | **2021** |
| Early | 3.78 | 3.42 | 35.81 | 25.68 | 0.81 | 0.57 | 61.46 | 54.71 |
| Late | 6.94 | 6.41 | 57.37 | 37.74 | 1.26 | 0.85 | 72.75 | 71.18 |
| Residue Removal | 6.68 | 6.37 | 58.96 | 36.74 | 1.22 | 0.81 | 70.26 | 68.88 |

- Plots were 10m long and 3.3m wide. A no-till drill was used to plant corn (Dekalb "DKC64-35RIB") at 74,100 seeds ha$^{-1}$ in late May for 2018 and 2019, and mid-May for 2020 and 2021.
- All N application to the corn was at sidedress timing (corn V4-V5 stage) using liquid urea ammonium nitrate (28-0-0) and this was between June 16 to 18 for 2018, 2020 and 2021. the application was done July 1 in 2019 because of the rainfall pattern in 2019.
- Soil samples were collected using a soil probe (0-30 cm depth) prior to sidedress application (PSNT) and deep core soil samples (0-90 cm depth) were collected at the end each season to assess leaching potential from plots with the various N application treatment plots.
- LAI and plant height were measured 8 times during the growing seasons.
- The corn was machine-harvested [8-XP Plot Combine (Kincaid, Haven, KS, USA)] on 13 November 2018, 10 October 2019, 3 November 2020, and 8 October 2021, when corn was physiologically matured.
- EONR Calculation: Net return is calculated from N causing corn yield increase minus fertilizer N cost. The point of maximum return to N (MRTN) is the economic optimum N rate (EONR).

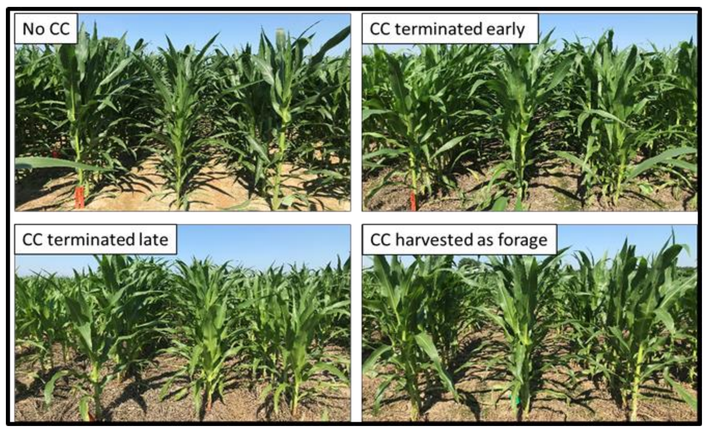


**Figure 1.** Corn in each cover crop treatment in 2018.

## Results and Discussion

*Corn yield was highest in the fallow treatment for all four years and equally had the lowest EONR value except in 2019 where rainfall affected the corn season (Fig. 2). Corn after the residue removal treatment was consistently underperforming suggesting removing the residue negatively affects corn yield and N need.*

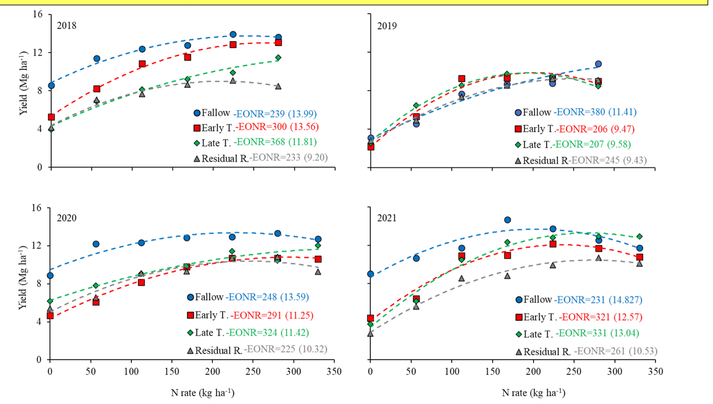


**Figure 2.** Corn yield at each nitrogen application rate for each cover crop management treatment and corresponding EONR value for all four years of study (2018, 2019, 2020 and 2021).

*The end of season nitrate-N for fallow treatment tend to rapidly increase (linearly or exponentially) after EONR rate has been deduced when regressed with N balance, indicating excess nitrate-N from over application of N fertilizer. For the other cover crop treatments there is mostly flat or less linear increase nitrate-N concentration despite the higher N rates because of N-immobilization. 2019 being an exceptional year due to excessive rainfall (Fig. 3).*

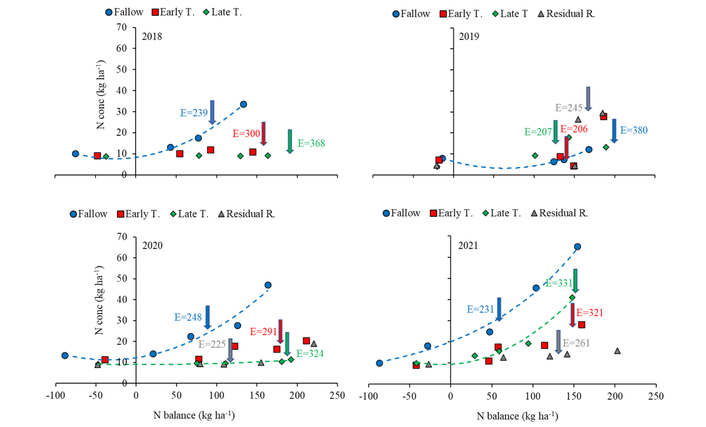


**Figure 3**. End of season Nitrate-N concentration as influenced by N-balance at each N application rate for each of the cover crop treatment in 2018, 2019, 2020, and 2021.

*Corn was always taller and had greater LAI in the fallow treatment reflecting on the higher corn grain yield (Fig. 4). Residue removal consistently had smaller plants and LAI suggesting possible growth inhibition mechanism (Fig. 4) that requires future investigation.*

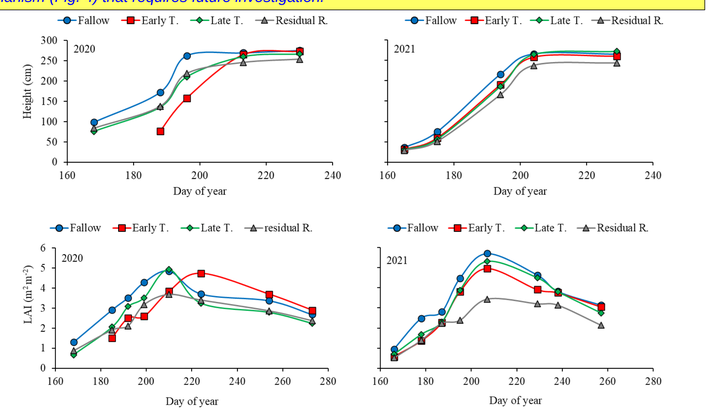


**Figure 4**. Corn height and LAI over the corn growing season in 2020 and 2021 as influenced by wheat management compared to no cover crop control (fallow).

## Conclusion and Future Research

- The EONR for fallow is less than other cover crop treatments resulting from yield penalty with inclusion of wheat. This can be compensated in some years but not consistently.
- The higher N requirement by the other cover crop treatments (except fallow) may likely result in higher N balance but not higher end of season nitrate-N because of N-immobilization induced by high above- and below-ground C-N ratio of the prior wheat.

## References

- Adeyemi, O., R. Keshavarz-Afshar, E. Jahanzad, M.L. Battaglia, Y. Luo, and A. Sadeghpour. Effect of wheat cover crop and split nitrogen application on corn yield and nitrogen use efficiency. Agronomy 10, no. 8 (2020): 1081.
- Illinois Nutrient Loss Reduction Strategy: November 2014 Press Release. https://www2.illinois.gov/sites/agr/Resources/NutrientLoss/Pages/default.aspx (accessed 30 Oct. 2021)